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Conservation Assessment for the Silver-Haired Bat in the Black Hills National Forest South Dakota and Wyoming

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for the
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INTRODUCTION

This conservation assessment for *Lasionycteris noctivagans* addresses the biology of the silver-haired bat across its range in North America, with emphasis on its biology and conservation status in the Black Hills of South Dakota and Wyoming. The purpose of this assessment is to assimilate current knowledge about this species from various sources to provide an informed and objective overview of this species' status within the Black Hills. Primary literature (peer-reviewed scientific publications) was the main information source utilized and all sources are cited. However, to ensure as complete coverage possible, other sources such as reports submitted to various agencies such as the Black Hills National Forest and the South Dakota Game Fish and Parks, were examined and information used from these sources is cited so that the reader can individually assess the value of such information. Information from academic documents such as Masters Theses and Doctoral Dissertations also was considered and incorporated where appropriate, with full citations. Finally, government-operated websites such as those for the Center for Disease Control (CDC) were accessed to obtain current information not available from the aforementioned sources.

While there is perhaps more information about *Lasionycteris* from the Black Hills region than for most other species of bat, extrapolation about certain aspects of this bat's biology from other areas within its range was necessary. Where specific kinds of information were lacking for the Black Hills region, such information from other parts of its range was provided when available. Furthermore, even when certain aspects of the silver-haired bat's biology are reported from the Black Hills region, information about variation in those aspects across the range of the species are included, to provide a comprehensive view of this species.

CURRENT MANAGEMENT SITUATION

Management Status

Throughout this species' range, silver-haired bats are considered "common" although local density estimates are largely lacking. The status of silver-haired bats as year-round residents in the northern Great Plains and the Black Hills region has not been determined. Surveys of caves and mine shafts during the winter have failed to find this species overwintering in the Black Hills (Martin and Hawks 1972). It is known that this bat is present in these regions, with peak activities observed during the spring and fall migrations, and that maternity colonies occur throughout the area during the summer.

Existing Management Plans, Assessments, Or Conservation Strategies

No existing management plans, assessments, or conservation strategies for *Lasionycteris* were found. South Dakota Game Fish and Parks, in cooperation with the South Dakota Bat Working Group, the Rocky Mountain Research Station in Rapid City, and other entities, is in the early stages of developing a statewide management plan for bats which will include the silver-haired bat. This document is not anticipated to be complete until July 2003.

REVIEW OF TECHNICAL KNOWLEDGE

Systematics

Lasionycteris noctivagans is the sole member of the monotypic genus *Lasionycteris*, belonging to the subfamily Vespertilioninae within the family Vespertilionidae. The type locality for this species is “Eastern United States” (Wilson and Reeder 1993). The most frequently used common name for this species is “Silver-haired Bat.” There are no bats with which this species could be easily confused in the Black Hills. The ears, wings and interfemoral membrane are black, while the hairs are dark brown to black and tipped with silver/white on the dorsum. Dorsal frosting is more pronounced in younger bats (Kunz 1982). Some bats, probably old individuals, have dark brown hairs with yellowish tips (Barbour and Davis 1969). The interfemoral membrane is furred above on the basal half, with hairs sparse enough that the membrane can be easily seen (Kunz 1982; Barbour and Davis 1969). External measurements (in mm) for this species are as follows: total length 92-115; length of tail 35 – 45; length of tragus 5-9 (Kunz 1982; Pearson 1962) and length of forearm 37-44mm (Barbour and Davis, 1969). Average and extreme measurements (mm) for 10 specimens taken from western South Dakota (Jones et al. 1983) are: total length 100.6 (91-108); length of tail 40.8 (38-45); length of forearm 40.4 (38.7-42.3). The only species with which this bat might be confused is the Hoary Bat (*Lasiurus cinereus*) which is much larger, and which has an interfemoral membrane that is thickly furred over the entire dorsal surface (Barbour and Davis 1969).

Distribution And Abundance

Distribution Recognized In Primary Literature

Overall Range

This bat is distributed over southeastern Alaska and the southern half of Canada, all but the southernmost portions of the contiguous United States, and into northeastern Mexico. Marginal records, with assumed and/or documented ranges in between, include British Columbia: Charlie Lake (Cowan 1939); roughly east to New Brunswick: St. John County (Morris 1948) southward along the eastern coast of Canada and the US, to but not including the southernmost corner of South Carolina, then southwesterly to Alabama: Autaugaville (Howell 1921); Louisiana: (over) east fork of Six Mile Creek in Vernon Parish (Lance and Rogowski 1999); Texas: near Bandera in Medina County (Davis 1978); westward to the foothills of the Chiricahua and Santa Rita Mountains (Hoffmeister 1970) of southern Arizona and on to California and northward along the west coast back up to British Columbia (Hall 1981). Extralimital records from Bermuda are thought to be due to groups of migrating *Lasionycteris* wandering out to sea during the spring migration (Nowak 1994). The winter range of this bat apparently extends into central Tamaulipas, Mexico (8.1km WSW Las Carricitos in the San Carlos Mountains; Yates et al. 1976). It is interesting to note that Genoways and Jones (1972) failed to capture this species during extensive collecting in southwestern North Dakota.

Local Distribution

Silver-haired bats are recorded from all regions of the Black Hills of South Dakota including Custer, Fall River, Lawrence, and Pennington Counties (Jones and Genoways 1967; Turner and Jones 1968; Turner 1974). While early authors suggested that silver-haired bats found in the Black Hills were transient, Turner and Jones (1968) reported a hibernating solitary male taken from a cave in Pennington Co., and Mattson et al. (1996) identified both maternity and solitary roosts of *L. noctivagans* observed during summer in Custer County. It possible that this species is a year-round resident of the Black Hills. Tracking of individuals to determine year-round

resident status is needed.

Additional Information From Federal, State, And Other Records

Neither the Wyoming Natural Heritage Database (online 2002) nor the Wyoming Game and Fish Department (Luce et al. 1999) lists *Lasionycteris noctivagans* as a species of concern or as having special management status. Records kept by the South Dakota Game, Fish and Parks show captures or sightings of silver-haired bats in all South Dakota counties of the Black Hills from June through September. Mattson and Bogan (1993) reported that *Lasionycteris noctivagans* was the most frequently captured species in the southern Black Hills during the summer of 1993, with males captured outnumbering females captured by about 2 to 1.

Estimates Of Local Abundance

Comments on abundance of this bat are typically qualitative or comparative. Barbour and Davis (1969) characterized *L. noctivagans* as erratic in abundance throughout much of its range, but suggested that highest abundance occurs in the northern Rockies from Wyoming and Idaho northward. Schowalter et al. (1978a) reported it as a common resident of the southern halves of Alberta and British Columbia. Merriam (1884; as cited in Kunz 1982) reported it as the most common bat in the Adirondack region of New York. Bailey (1929) reported *L. noctivagans* as the second most abundant bat, after *Myotis lucifugus*, in Minnesota. Kunz (1973) reported relative abundances of *Lasionycteris* at three areas in central Iowa as 21 at Area A, 64 at Area B, and 120 at Area C [relative abundance = (number of *Lasionycteris* individuals captured / number of net-nights) x 100]. Clark and Stromberg (1987) concluded that the bat is probably abundant in Wyoming.

Habitat Associations

In general, this species is most commonly associated with forested areas and/or montane habitats with water available. Barclay (1993) included *Lasionycteris noctivagans* in his discussion of prairie bats and concluded that prairie populations rely on trees in riparian areas and around farms (shelterbelts). In western South Dakota, Turner and Jones (1968) reported grassy valleys surrounded by well-forested hillsides of ponderosa pine and containing a source of standing water as preferred foraging sites. Specific habitat features important in roost site selection by this species are described below under Roosting Ecology.

Roosting Ecology

Maternity Roosts

Mattson et al. (1996) used radiotelemetry to locate 39 roosts in Custer Co., SD. Ten of these were maternity roosts with 6-55 (average of 22.2 ± 4.9) individuals. Maternity roosts located in this study were found exclusively in tree cavities, most of which were developed by woodpeckers. The openings to these cavities were typically located on the south side of the tree, were 7.5-10cm in diameter and were located 10.2 ± 1.5 m aboveground. All but one of the roosts identified by Mattson et al. (1996) were in ponderosa pine (*Pinus ponderosa*); however, the prevalence of this tree species in the study areas precluded any statements about species preference by silver-haired bats. Instead, Mattson et al. (1996) suggested that the bats select trees based on structure rather than by species. Maternity roosts occurred in trees that were standing, dead, and had a mean dbh of 44 ± 4 cm. Forest stands supporting silver-haired bat roosts typically had a snag density of 21 snags/ha, and contained a higher total basal area than surrounding plots. Unlike solitary bats (see below) which switched roosts frequently, maternity

aggregations stayed in the same roost for longer periods of time; however, some did switch at least once during the reproductive period (Mattson et al. 1996). Studies by Campbell et al. (1996) in northeastern Washington and Betts (1998) in northeastern Oregon, suggest that silver-haired bats select for maternity roosts trees that are taller than surrounding trees, have fewer tall trees around them, and surrounding understory that is shorter and less dense. These characteristics are hypothesized to increase insolation and hence warmth of the maternity roost, and to provide less clutter through which newly volant young and adult females must navigate to reach the roost. Although Mattson et al. (1996) suggested that physical features of potential roost trees may be more important than tree species, the results reported by Campbell et al. (1996) and Betts (1998) do support a preference for ponderosa pine. Vonhoff (1996) reported on roosting ecology of silver-haired bats in the Pend d'Oreille Valley (POV) of southern British Columbia. In the POV, *Lasionycteris* preferred trembling aspen (*Populus tremuloides*) and lodgepole pine (*Pinus contorta*). Roost site characteristics included larger diameter trees, reduced tree densities, more canopy gaps, and less clutter (Vonhoff 1996).

Hibernacula

Across their range, hibernating *Lasionycteris noctivagans* have been found in basements of buildings (Virginia; Bartsch 1956), in silica mines (Illinois; Pearson 1962), in shallow caves in sandstone cliffs (Minnesota; Beer 1956), in limestone caves (South Dakota; Turner 1974), and under loose bark of giant cedars (British Columbia; Cowan 1933). There are no reliable reports of large winter aggregations (Barbour and Davis 1969; Griffin 1940; Kunz 1982). Studies are needed which characterize hibernacula utilized by *L. noctivagans* in the Black Hills if such exist.

Day Roosts (Of Males And Non-Reproductive Females)

Most studies of roosting behavior have either focused on maternity roosts or have not distinguished between maternity roosts and summer (day) roosts. However, Mattson et al. (1996) did track and locate the roosts of males and apparently non-reproductive females, hereafter referred to as 'solitary bats.' The majority of solitary bat roosts identified by Mattson et al. (1996) occurred under loose bark (n=15), while tree cracks or crevices (n=5) and woodpecker cavities (n=1) were utilized less frequently. Solitary bats switched roosts frequently, but returned to trees used several days previously.

Night Roosts

As stated above, most studies conducted on roosting behavior have focused on maternity roosts. In addition, radiotracked bats are typically located to a specific tree during the day. The use of night roosts by males and nonreproductive females, as well as verification of the maternity roost assumption, are areas in need of further investigation.

Interim Roosts

As most studies have focused on maternity roosts, virtually nothing is known about characteristics of interim roosts – roosts used while moving from hibernacula to summer grounds in the spring, and on the return trip in the fall – used by this species. This is an area that warrants further investigation.

Foraging Habits

Silver-haired bats tend to forage close to ponds, slow streams, and other sources of water in coniferous and mixed deciduous forests (Jones et al. 1983, Clark and Stromberg 1987, Nagorsen and Brigham 1993). Turner and Jones (1968) reported that silver-haired bats in the Black Hills

region preferred grassy valleys surrounded by well-forested hillsides of ponderosa pine and containing a source of standing water. However, these reports are based largely on anecdotal information. There is a paucity of systematically collected data on foraging habits and habitats of silver-haired bats in the Black Hills region.

Prey Species

Black (1974) characterized *Lasionycteris noctivagans* as a “moth strategist.” Subsequent studies reinforce the importance of Lepidoptera as the primary prey order in the diet of silver-haired bats, but also demonstrate that this bat is somewhat opportunistic in its feeding, preying upon Homoptera, Hymenoptera, Hemiptera, Diptera, Neuroptera, Isoptera, Trichoptera, Orthoptera, and Coleoptera (Jones et al. 1973; Whitaker et al. 1977; Whitaker et al. 1981; Warner 1985), in addition to moths. Variance in the relative take of these groups by silver-haired bats is assumed to relate to availability of the prey items. Two families of arachnids (harvestmen and spiders) were also consumed by bats examined by Whitaker et al. (1977) in western Oregon. Novakowski (1956) reported observing young bats feeding on dipteran larvae occurring in the bottom of their roost which was an abandoned woodpecker hole.

Characteristics Of Prey Species

Freeman (1981) conducted principal components analysis of 14 cranial measurements of 41 species of vespertilionid bats and then regressed the PC loadings against a prey hardness scale. The first principal components axis related to robustness of the skull, with bats on the negative end having more robust skulls, and bats on the positive end having more “gracile skulls” (Freeman 1981). *Lasionycteris noctivagans* fell out on the first principal components axis at a value of about +0.15-0.2 indicating a mildly gracile skull. The fact that silver-haired bat skulls are not highly gracile (loading closer to +1) suggests morphological ability to take a variety of prey items. Freeman (1981) also ranked the hardness of the prey items for these 41 bat species on a scale of 1 (softest; e.g. Neuroptera and Diptera) to 5 (hardest; Coleoptera), and calculated a weighted average of the food habits for each species. According to this scheme, *Lasionycteris noctivagans* prey items had a weighted average of 1.75, indicating variety in prey items, with most prey being “soft-bodied.”

Reproduction And Development

Life History Characteristics

Silver-haired bats are reproductively k-selected, with each reproductive effort producing 1-2 offspring; two being the typical number for this species (Kunz 1982). The sex ratio is equal at birth (Kunz 1971; Schowalter et al. 1978a). Most young males and females appear to mature sexually during their first summer (Druecker 1972). Adult males and females of this species appear to segregate except during spring and fall, with females outnumbering males in summer populations in areas other than the montane west (Kunz 1971, 1973; Jones 1965, 1966; Jones et al. 1973). While some temperate zone vespertilionids are known to live for 20-30 years, the lifespan of this species is unknown. Schowalter et al. (1978b) used dental annuli to estimate that the majority of the individuals examined were 2 years old; the oldest was placed in a 12-year age class. Comparisons of age structure based on dental annuli of *L. noctivagans*, *Eptesicus fuscus*, and *Myotis lucifugus* indicated that the silver-haired bat has the shortest lifespan of the three species (Schowalter et al. 1978b).

Survival And Reproduction

Most temperate zone vespertilionids have a primary mating period in the fall before entering hibernation. Some copulation may occur during the winter when males temporarily arouse from hibernation, however, this is considered of minor importance relative to overall breeding. In these fall-breeding bats, sperm are stored by the female until ovulation occurs in the spring.

Lasionycteris noctivagans appears to follow this pattern, with a peak of sperm formation in late August and of ovulation in late April and early May (in New Mexico; Druecker 1972). Gestation is approximately 50-60 days (Druecker 1972). Pregnant females have been reported in May and June in New Mexico (Druecker 1972), in May and June in Iowa (Kunz 1971; Easterla and Watkins 1970), in May in Minnesota (Bailey 1929), in late June in Michigan (Kurta and Stewart 1990), and parturition in British Columbia is estimated to occur in late June or early July (Nagorsen and Brigham 1993; Schowalter et al. 1978a). Kunz (1971) reported a median parturition date of 16 June and a lactation period of approximately 36 days. Young are capable of flight at 3-4 weeks and were first captured in late July (Kunz 1971).

Kurta and Stewart (1990) observed parturition in a captive silver-haired bat. The pregnant female delivered one day after having been mist-netted. She delivered two young, a female first and a male second; both breech as is typical for bats. Total delivery time (from beginning of first neonate exiting birth canal to end of second neonate exiting birth canal) was 44 minutes. The female neonate was successful in reaching and attaching to the left nipple. The male neonate was not as vigorous, became entangled in the still-intact umbilical cord, and eventually died probably due to lack of nourishment or water (Kurta and Stewart 1990).

Mortality between conception and fledging probably accounts for the difference in estimates of number of offspring between Druecker's (1972; based on embryos per female) estimate of 1.84 and Kunz's (1971; based on ratio of volant young to adult females) estimate of 1.7. Pulses of carcasses submitted for rabies testing during spring and fall indicate that additional mortality may occur during migration of this species (Dorward et al. 1977, Kunz 1982, Bogan and Cryan 2000)

Local Density Estimates

Local density estimates are not available for this species. The tendency of silver-haired bats to roost alone or in very small numbers makes estimates of density difficult. This is an area of this bat's biology that needs considerable work.

Limiting Factors

Although limited information is available for many aspects of this species' ecology that may affect its numbers and distribution, one limiting factor for *Lasionycteris noctivagans* appears to be the availability of suitable trees for maternity roosts (e.g. Mattson et al. 1996). Although not species specific, the physical characteristics of the tree and its surroundings appear to be important in selection for maternity roosts. For details of maternity roost characteristics, see Roosting Ecology – Maternity Roosts (above).

Patterns Of Dispersal

Patterns of dispersal, beyond that it does migrate, are not known for this species, as indeed they are known for very few microchiropterans. New technologies are available to facilitate studies in this area, but would require considerable funding and logistical support.

Metapopulation Structure

As with patterns of dispersal, which would contribute to our understanding of this aspect of the silver-haired bat's biology, metapopulation structure is unknown. Again, molecular techniques are available to address these questions, but would require substantial funding and time.

Community Ecology

Predators

Sperry (1933) reported that a skunk (*Mephitis mephitis*) captured on January 22, 1930 in the Pisgah National Forest of North Carolina had eaten two silver-haired bats. Although the bats were in pieces, the entire bodies had been consumed. This report indicates that silver-haired bats hibernate in North Carolina and that they are vulnerable to predation during hibernation. Bond (1940) reported great horned owls preying on silver-haired bats. Bell (1980) described an aerial attack on *Lasionycteris* by a rabid red bat (*Lasiurus borealis*). Although not documented, it is highly likely that silver-haired bats, particularly newly- but not necessarily proficiently-volant young, are susceptible to a variety of predators, both aerial and terrestrial (e.g. snakes).

Competitors (e.g. For Roost Sites And Food)

Given their nocturnal insectivorous niche, bats probably face the greatest threat of competition for food *resources* from other species of bats, although bats have been observed to apparently compete with insectivorous birds during the transition period between day and night (Van Gelder and Goodpaster 1952). Such interactions between bats will be discussed below under "Other complex interactions." A number of other species (e.g. *Myotis evotis*, *M. septentrionalis*) occurring in the same range as *Lasionycteris* also utilize loose bark as roosting sites (Jones et al. 1983). No studies specifically documenting competition for roost sites between *Lasionycteris* and other species of bats have been published (but see discussion below under "d. Other complex interactions").

Parasites, Disease

Documented ectoparasites summarized by Kunz (1982) include two species of mites, bat flies from the families Nycteribiidae and Streblidae, and two species of bat bugs from the family Cimicidae. Endoparasites included one species of nematode, seven trematodes, and three cestodes (Kunz 1982 and references therein). Rabies has been reported for *Lasionycteris* from many parts of its range. Across the species' range, most cases are documented in August through October and correspond to the peak fall migration time for this species (Kunz 1982). Dorward et al. (1977) conducted a comprehensive study of rabies in bats of Alberta between 1971 and 1975. Data for *Lasionycteris* were based on bats submitted for rabies examination. In this study, the percentage of *Lasionycteris* examined for rabies which were rabies-positive ranged from 4.8% to 12.3% between 1973 and 1975, with an overall average of 9.9% for a total of 222 bats examined (Dorward et al. 1977). Silver-haired bats were submitted in June through October, with the majority of the bats caught in September and a gap between 16 July and 13 August during which no *Lasionycteris* were submitted. Frequency of rabies varied by age and gender with the majority being juvenile (84.2%) and female (68.4%; Dorward et al. 1977). In general, frequency of rabid silver-haired bats was greater during the fall migration than during the spring migration (Dorward et al. 1977). Two cases of bat-related rabies were reported from the Black Hills region in 2000, however, neither the species of bat nor the rabies strain (e.g. Ln/Pi for the strain identified to occur in *Lasionycteris* and *Pipistrellus*) was identified for either case (<http://www.cdc.gov/ncidod/dvrd/rabies/Professional/Surveillance00/text00.htm>). Nationwide, rabid *Lasionycteris* comprised only 2% of the rabid bats reported to the CDC in

2000 (<http://www.cdc.gov/ncidod/dvrd/rabies/Professional/Surveillance00/text00.htm>).

Other Complex Interactions

Kunz (1973) studied temporal and spatial aspects of bat activity in central Iowa relative to resource utilization. His study demonstrated that *Lasionycteris* and *Myotis septentrionalis* overlap substantially in their temporal foraging patterns. Both species displayed bimodal activity with the first pulse at 0-4h after sunset (with *Lasionycteris* becoming active later than *M. septentrionalis*) and a second pulse at approximately 7-8h after sunset. Kunz (1973) suggested that these bats may spatially partition the food resources as some bats have been documented to utilize 'foraging territories' (e.g. *Eptesicus fuscus*; Barbour and Davis 1969).

Reith (1980) conducted a study to address whether or not competition did occur between *Eptesicus fuscus* and *Lasionycteris noctivagans* in southcentral and southwestern Oregon by comparing timing and duration of foraging activities for *Lasionycteris* at sites where the two species were allopatric versus sites where they were sympatric. His results indicated that *Lasionycteris* began foraging activities later and foraged for a longer period of time at sites where *Eptesicus* also occurred. He concluded that competition between the two species for limited food resources was the most parsimonious explanation for the longer duration of foraging by *Lasionycteris* when the two bats were in sympatry. However, no insect availability data were collected to support or reject this conclusion. Reith (1980) also suggested that the later initiation of foraging activity may be due to roost displacement by *Eptesicus*, such that the silver-haired bats had to travel farther to reach the foraging areas.

Roost Site Vulnerability

Roosts of silver-haired bats are vulnerable to predators and to ectoparasites. Switching among roost sites, particularly of maternity roosts, is thought to be a mechanism for counteracting this vulnerability (Mattson et al. 1996; Lewis 1995). Selection of tree cavities above the canopy and in areas of relatively short understory may reduce predation by terrestrial predators (Betts 1998). Vonhoff and Barclay (1996) suggested that roosts that opened to uncluttered areas may provide protection from aerial predators by providing a clear flight path back to the safety of the roost. Campbell et al. (1996) indicated that this may be particularly important for newly-volant young.

Risk Factors

Lack of region-specific data about many aspects of silver-haired bat ecology prevents much discussion about potential risk factors. However, one risk factor that is apparent from the data available for this species in the Black Hills region is the loss of potential roosting sites through both natural and anthropogenic processes.

Studies on the roosting ecology of this species indicate that roost trees, either maternity or solitary, are typically larger than average in diameter, taller, and in decay classes 4-7 (Campbell et al. 1996, Mattson et al. 1996, and Betts 1998). For more specific details of roost sites, see Roosting Ecology (above).

Location of trees on the landscape and their immediate surroundings are also important. Mattson et al. (1996) found that roost trees tended to be located at higher elevations than random points. Furthermore, their study indicated a preference for cavities that opened to the south. Both of these characteristics were hypothesized to increase insolation, resulting in warmer roosts and consequent energy savings that could be devoted to growth and development (Mattson et al. 1996). Studies by Mattson et al. (1996), Campbell et al. (1996) and Betts (1998) combined to

indicate that preferred roost trees are surrounded by areas with less closure of overstory canopy (due to roost trees being distant from neighboring tall trees), and understory that was not as dense and was shorter than non-roost sites.

Response To Habitat Changes

Management Activities

Timber Harvest

Timber harvest can have beneficial or detrimental impacts on *Lasionycteris noctivagans*, depending on application. Timber harvest which promotes forest with lower density of trees overall, and relatively greater numbers of mature trees, can help provide suitable roosting sites for these bats. Additionally, recruitment and retention of snags was recommended by Campbell et al. (1996) as well as Mattson et al. (1996).

The Black Hills National Forest's 2001 Phase I Amendment to the Land Resource Management Plan ROD 3/97 (LRMP-ROD 3/97: US Forest Service 1997), implementing the selected alternative (Alternative 2), increased the number of acres for Commercial Thinning and Regeneration Opening, while reducing the number of acres for Overstory Removal, Shelterwood Seed Cut, and Seed Tree Cut. Increased areas of commercial thinning, as long as these activities take place during October through mid-April, would not be anticipated to negatively impact silver-haired bats. Regeneration openings may provide temporary foraging areas for silver-haired bats, particularly if they are close to roosting areas and standing, open water. Harvest activities which reduce the amount of mature forest with tall, large-diameter snags surrounded by relatively sparse and short understory, may negatively impact *Lasionycteris noctivagans*. Again, timing of harvest activities is important because these bats are known to use the trees as maternity roosts and as solitary roosts primarily during the months of May through September in the Black Hills. Furthermore, the avoidance of trees used as maternity roosts may be important because some species of bats have been documented to roost in the same tree over a period of years (Willis et al. 2002).

The 2001 Phase I Amendment to the LRMP increased minimum hard snag requirements to 2 snags/acre for Ponderosa Pine forest on south and west slopes, and 4 snags/acre on north and east slopes (US Forest Service 2001). Recommended average snag densities of 2-4 hard snags per acre (Phase I Amendment LRMP) were far below the minimal snag density of 21 snags/ha reported by Mattson et al. (1996) for this species in the Black Hills National Forest. The 2001 Phase I Amendment also specified that minimum snag diameter is greater than 25cm (10 inches), and requires that 25% of the snags be greater than 50cm (20 inches) in diameter, or in the largest size class available. The average dbh of maternity roost snags reported by Mattson et al. (1996) in the Black Hills was 44 ± 4 cm (range of 29-62cm). For snag characteristics reported by Mattson et al. (1996) and specific to the Black Hills, see Roosting Ecology – Maternity Roosts (above). While Mattson et al. (1996) did not make specific management recommendations *per se*, Campbell et al. (1996) recommended expansion of snag management guidelines from riparian areas to upland areas, as all roosts in their study (in the Selkirk Mountains of northeastern Washington) were greater than 100m from riparian zones.

Recreation

No studies were found which addressed the impacts of recreational activities on *Lasionycteris noctivagans*. Fortunately, bats are nocturnal while humans are primarily diurnal. This fact alone

may ameliorate potential impacts of recreational activities. Furthermore, the fact that these bats tend to roost solitarily or in small groups in snags at heights of 6m or greater above the ground (Campbell et al. 1996), removes them, for the most part, from recreational disturbances. It is anticipated that light recreational activities (e.g. horseback riding, hiking, mountain biking) would not negatively impact silver-haired bats unless they are associated with nocturnal activities around water sources or with activities that degrade water sources. Recreational activities that are anticipated to have a higher potential for negative impact would be those that might disturb the bats indirectly in their roosts such as dirt biking, four-wheeling, and discharging firearms. All of these activities produce noise levels which may disturb maternity colonies of bats, and the improper use of off-road vehicles can lead to erosion and, consequentially, degradation of water sources.

Livestock Grazing

No studies were found which addressed the impacts of livestock grazing on silver-haired bats. Livestock grazing may indirectly benefit bat species through the construction of additional water sources (Chung-MacCoubrey 1996). The impact of livestock grazing on bat food resources is an area in need of research.

Mining

There are no currently published studies which directly address the impact of mining activities on *Lasionycteris noctivagans*. If silver-haired bats are determined in the future to be year-round residents of the Black Hills and to utilize caves and mines as hibernacula, then the impact of mining activities on this species should be carefully examined. At this point in time, however, silver-haired bats are not known to hibernate in any substantial numbers in the Black Hills.

Prescribed Fire

To date, studies directly assessing the impact of fire regimes on silver-haired bats are not available. However, given that these bats prefer more open, mature forest with standing dead trees, such as might be maintained by regular prescribed burns, it could be argued that prescribed fire could benefit this species. If fires are frequent enough to reduce the fuel load such that fires are of low enough intensity that large snags are not burned, then the reduction in understory density and height, and the maintenance of a more open forest would be anticipated to provide more suitable roosting sites for *Lasionycteris noctivagans*.

Fire Suppression

As mentioned above, the impact of various fire regimes on *Lasionycteris noctivagans* has not been studied directly. However, Bock and Bock (1983) reported that fires occurred naturally in the Black Hills about every 10-25 years between 1820 and 1910. Brown and Sieg (1999) estimated fire intervals of 10-12 years in the ecotone between forest and prairie in the southeastern Black Hills, and intervals of roughly 19-24 years for more interior forest (near Jewel Cave) in the southern Black Hills. Suppression of fire in this region can produce doghair stands of ponderosa pine which are not suitable roosting or foraging habitat for silver-haired bats. In addition, when fires do occur in areas where fire suppression has been practiced, the fires are more likely to be large, hot burning fires that would destroy suitable roosting habitat for *Lasionycteris*. Thus, fire suppression in the Black Hills may be more of a detriment than a benefit to the silver-haired bat populations of this region.

Non-Native Plant Establishment And Control

The effect of exotic plant establishment and control on populations of *Lasionycteris noctivagans* has not been studied. However, given the ability of some exotic invasives to completely change habitat use by species of wildlife (e.g. Trammel and Butler 1995), and their ability to establish a monoculture which may support a different or reduced insect prey base, it would not be surprising to find that there is indeed an impact. Future studies in this area would be of interest.

Pesticide Application

Henny et al. (1982) reported an increase in DDT metabolite residues in carcasses of *Lasionycteris* following a single DDT spray application northeastern Oregon, eastern Washington, and northern Idaho during June and July of 1974. No studies directly addressing the impact of bioamplification or bioaccumulation of currently used pesticides on silver-haired bats were found. However, given this bat's opportunistic insectivory, including midges with significant bioaccumulation potentials, this is an area that is in need of further study.

Fuelwood Harvest

No studies directly addressing the impact of fuelwood harvest on *Lasionycteris* were found. However, if fuelwood harvest allows the removal of standing dead trees, which it typically does, then this activity has the potential to negatively impact silver-haired bats by removing potential roosting sites. Fuelwood harvest or other silvicultural practices which permit only the removal of downed trees, or of snags under 29cm dbh, may positively impact these bats by removing fuel load and thus reducing the potential for hot burning wildfires which would burn larger snags that serve as potential roost sites for these bats.

Natural Disturbance

Insect Epidemics

No literature was found which deals with the impact of insect epidemics on silver-haired bats. Within the Black Hills, outbreaks of mountain pine beetle (*Dendroctonus ponderosae*) and pine engraver beetle (*Ips pini*) could be predicted to have a detrimental impact on *Lasionycteris* if the outbreaks went unchecked to the point that large areas of ponderosa pine were killed and downed. In the interim, die-off of trees might provide a larger number of potential roosting sites and reduce potential competition with other cavity-nesting species. It is not known whether or not silver-haired bats take either of these insect pests during normal foraging.

Wildfire

No literature is available which specifically addresses the impact of wildfires on populations of *Lasionycteris noctivagans*. However, given this bat's evident preference of mature, open forest with a relatively high density of snags for roosting sites, certain predictions about the role of wildfire in the habitat ecology of silver-haired bats can be made. Early photographs from the Black Hills region indicate that many forested areas were more open with snags (Knight 1994). As mentioned above under Prescribed Fire and Fire Suppression, the latter leads to doghair stands of ponderosa pine which are unsuitable as roosting habitats for *Lasionycteris*. Furthermore, accumulation of fuel load results in wildfires burning much hotter and the potential for these wildfires to destroy large areas of suitable silver-haired bat habitat. Frequent fires, similar to the fire regime in pre-settlement times (every 5-25 years; Knight 1994) would keep the fuel load reduced while maintaining the more mature and open forest apparently preferred as roosting habitat by silver-haired bats.

Wind Events

While no literature directly addresses the effects of wind events on silver-haired bats, the spatial scale of such events would probably determine the consequences for *Lasionycteris*. Small-scale events which break or down occasional trees would probably not have a detrimental effect on silver-haired bats, and may provide more roosting habitats if trees are not broken too low. On the other hand, large-scale events which down all or most of the trees in an area would be predicted to have a detrimental impact on this species.

Flooding

No literature is available that addresses the impact of flooding on *Lasionycteris noctivagans*. Most roost sites of this species are greater than 100m upslope from riparian zones (Campbell et al. 1996), thus the direct impact on this species of flooding in the Black Hills should be minimal.

Other Weather Events

As this species occupies the Black Hills and regions considerably north and south of the Black Hills during the summer, it must be assumed that it has evolved to cope with the range of summer weather conditions experienced by the Black Hills region. The fact that silver-haired bats roost in enclosed cavities provides them protection from summer weather events such as hail which might kill exposed animals.

SUMMARY

Lasionycteris noctivagans is a seasonally abundant bat throughout its range which includes southeastern Alaska, the southern half of Canada, and most of the coterminous United States, into northern Mexico. Characterized as a migratory species, this bat is less common in northern reaches of its range during the winter, and is captured in those areas in the greatest numbers during spring and fall migrations. While silver-haired bats are considered stable over their range, South Dakota Game Fish & Parks does monitor this species. Although one individual of the species has been recorded from the Black Hills during the winter (Turner and Jones 1968), winter surveys of caves and other possible hibernacula have failed to produce hibernating silver-haired bats (Martin and Hawks 1972). As such, whether or not *Lasionycteris* hibernates in the Black Hills and whether or not some part of the population maintains year-round residency in the Black Hills is unknown.

Lasionycteris males and non-reproductive females tend to roost singly and utilize loose bark of trees, tree cracks and crevices, and tree cavities formed by other animals such as woodpeckers. Maternity roosts in the Black Hills are typically in ponderosa pine snags that are larger and taller than surrounding trees. Maternity roosts typically occur in mature forest with less and shorter understory than surrounding non-roost areas. The openings to these roosts are more often to the south, suggesting selection of roosts based on potential energy saving due to increased insolation.

Although characterized by some researchers as “moth specialists,” silver-haired bats consume a wide variety of insects, and will also take spiders and harvestmen. Most diet species are relatively soft-bodied. These bats forage over still and running water and in openings surrounded by forest. They require open, still water for drinking.

The factor most likely to limit *Lasionycteris* in the Black Hills is the availability of suitable roost sites. In the Black Hills, silver-haired bats primarily select as maternity roosts ponderosa pine snags with dbh averaging 44 ± 4 cm and height averaging 14.2m. These roost trees are in areas

of mature forest (lower density, large, tall trees) with low, sparse understory. Black Hills forest stands in which roosts occur typically have a density of 21 snags/ha or higher.

REVIEW OF CONSERVATION PRACTICES

Management Practices

A thorough review of the current scientific literature produced no examples of management practices implemented or evaluated for silver-haired bats. However, Vonhoff (1996) did propose management practices that, based on available research, may provide the best opportunity to conserve suitable roosting habitat for *Lasionycteris*. Vonhoff's (1996) recommendations included:

Selection Harvesting – following prescriptions that reduce understory and maintain areas of lower density, large-diameter trees with adequate canopy cover to retain a suitable microclimate.

Prescribed Fire – periodic, low-intensity burns to maintain open nature of forest stands.

Retention of large areas of forest with the above characteristics – small numbers of large trees left within cutblocks are not predicted to provide suitable roosting sites for this species.

Models

No predictive models have been developed for the comprehensive impact of habitat dynamics on *Lasionycteris noctivagans*. However, Vonhoff (1996) used stepwise discriminant function analysis to elucidate relative importance of roost tree/habitat variables for *Lasionycteris* in the Pend d'Oreille Valley in southern British Columbia. Vonhoff (1996) found that dbh accounted for 35% of the variation between roost and available trees from other areas of the same stand, while horizontal distance to nearest tree of same or greater height, horizontal distance to the nearest neighboring tree, and tree height accounted for 17-20% of the variation between roost and available trees in the immediate vicinity of the roost tree. This model may provide a template which could be modified based on data for *Lasionycteris* from the Black Hills. The needs for basic information to construct such models are discussed below under Additional Information Needs.

Inventory Methods

Inventory methods for silver-haired bats traditionally included mist-netting over water sources, and more recently, the use of ultrasonic bat detectors. Mist-netting is limited in its effectiveness by appropriate weather conditions and relative availability of water. Wind and rain make nets more visible to bats and reduce the ability to capture bats in the nets. In areas where numerous water sources are available, numbers of bats caught at any one water source can drop.

Acoustic inventory of bats provides advantages over mist-netting in that echolocating bats can be detected regardless of wind or rain. However, identification of echolocating bats to species requires the development of echolocation libraries for signal comparison, and the development of expertise on the part of the researcher in distinguishing among the echolocation sequences of the species in a given area. Incomplete call sequences can lead to erroneous species identification. Advances in molecular genetics are currently being implemented to facilitate determination of presence/absence based on assignment of fecal pellets from bridge and comparable roosts to species (Ormsbee et al. 2002).

Monitoring Methods

The use of Geographic Information Systems can greatly facilitate habitat monitoring, assuming the characteristics for high-quality silver-haired bat habitat are known. Current information about roosting requirements for this species may provide an adequate starting point for this form of habitat monitoring.

Methods previously discussed for determining presence/absence (mist-netting and acoustic detection) might be used indirectly, under very specific conditions, for evaluating population trends and persistence. However, no models are available to predict the amount of each method required to detect various percentages of change in population size. Monitoring methods based on radiotelemetry and/or mark and recapture may provide more information, but would also be very expensive, primarily in terms of personnel (time).

Regardless of the methodologies employed for inventorying and monitoring, it is critical that the study be designed and conducted by individuals with first-hand experience with the various techniques and detailed understanding of their assumptions and limitations.

ADDITIONAL INFORMATION NEEDS

Research needs discussed in the sections below are presented in Table 1 with prioritization and cost estimate categories. Research to address these needs should be developed with input by individuals with experience in experimental design, bat inventorying and monitoring techniques, experience in obtaining the particular kinds of ecological data required, and detailed knowledge of the literature available for the species in question.

Distribution

Current knowledge of the distribution of *Lasionycteris* in the Black Hills is based on a number of independent surveys and considered by some to be anecdotal. Distribution within the Black Hills has been shown to vary between years, presumably due to variation in weather, primarily temperature and rainfall. Tigner and Aney (1994) reported lower abundance (based on fewer captures/detections) of *Lasionycteris* in the northern Hills during 1993 relative to abundance in the southern Hills during the same summer (Mattson and Bogan 1993) and relative to captures/detections in the northern Hills during the summers of 1994 and 1995. The summer of 1993 was cooler and wetter than that of 1994 (Tigner and Aney 1994).

Systematic, coordinated surveys of the entire Black Hills area over a number of years are needed to fully understand the distribution dynamics of *Lasionycteris* in this region. These surveys should be designed to duplicate as closely as possible, the timing, duration, and methods used in the different districts of the Black Hills.

The question still exists as to whether or not *Lasionycteris* hibernates in the Black Hills. Although surveys of caves and mines during the winter have failed to produce hibernating silver-haired bats, this does not effectively eliminate the possibility that this species is a year-round resident in the Black Hills. *Lasionycteris* has been found hibernating under the bark of trees in regions to the north of the Black Hills. Thus, it is possible that they utilize similar resources for hibernacula in the Black Hills. Attaching radio transmitters to silver-haired bats late in September and tracking them to see if they migrate south or remain in the Black Hills may help answer the question of whether or not this species is a year-round resident in the Black Hills.

Species Response To Stand Level Changes

As we have only recently acquired data about roost requirements for this species, empirical knowledge about how *Lasionycteris* responds to stand level changes is yet to be achieved. Certainly, predictions (hypotheses) can be formed based on our current understanding of roost requirements, but testing of those predictions/hypotheses needs to happen.

Roosting Habitat Adaptability

Across its range, *Lasionycteris* utilizes a number of tree species for maternity and solitary roosts, suggesting a fair level of adaptability, at least to different species of trees. However, physical requirements of the roost trees appear to be relatively constant across the species range. These physical requirements include large-diameter trees which are taller than surrounding trees, which occur in low-density stands with greater basal area than random, and with sparse and short understory vegetation. Aspects of roost site ecology which still need to be addressed include:

- 1). Interactions between *Lasionycteris* as a secondary cavity dweller and primary cavity excavators (PCEs, e.g. woodpeckers) upon which they depend for creating potential roost cavities, and other secondary cavity dwellers (e.g. saw-whet owls). If forest systems are managed for the PCEs, does this necessarily mean that the needs of *Lasionycteris* are met? Does *Lasionycteris* face competition from other secondary cavity dwellers in the Black Hills?
- 2). Temporal and spatial dynamics of maternity roost re-use. *Lasionycteris* maternity colonies are known to move periodically, although not as frequently as solitary roosts. What factors influence the rate of movement among maternity roost sites (e.g. thermal regimes, parasites, predators)? What density of suitable maternity roost sites are required to support persistence of silver-haired bats?

Movement Patterns

As mentioned above under Distribution, there does appear to be variation in activity among the districts of the Black Hills depending on seasonal weather. Daily movement patterns have not been specifically studied in the Black Hills. Data on daily movement patterns would be best acquired by the use of radiotelemetry. This information is needed not only relative to determining requirements for roost sites, but also relative to foraging habitat requirements. Please see further discussion under Foraging Behavior below. Inter-seasonal movements might best be monitored with a combination of radiotelemetry and some form of mark-and-recapture. Attaching radio transmitters to silver-haired bats late in September and tracking them to see if they migrate south or remain in the Black Hills may help answer the question of whether or not this species is a year-round resident in the Black Hills. The use of PIT (Passive Integrated Transponder) tags and readers is increasing for study of small-sized wildlife species and may provide a more reliable long-term means of tracking individuals.

Foraging Behavior

Studies of foraging behavior of *Lasionycteris* in the Black Hills are needed. Studies on insectivorous bats of northern forests in other regions indicate that stand type and vertical structure are important (Kalcounis et al. 1999). Bat foraging studies available in the literature often fail to collect and analyze data about insect diversity and availability in conjunction with the bat diet studies. This information is needed to elucidate not only dietary preference, but also many other aspects of foraging ecology such as seasonal variation, differences between reproductive classes of individuals, and the potential for competition within and among bat

species, and with other insectivores such as crepuscular birds.

Demography

The demography of *Lasionycteris noctivagans* is not understood in sufficient detail to facilitate analysis of persistence of local population and metapopulation structure under alternative management directions.

Table 1. Priorities and cost categories of research needs.

SUBJECT	PRIORITY*	JUSTIFICATION	COST**
Distribution	Low	Determine extent of BHNF to be managed for <i>L. noctivagans</i>	Moderate
Hibernation in BHNF	Low	Determine hibernation status and habitat requirements	Low
Competition for Roosts	Low	Important factor in determining habitat area requirements	Moderate
Factors influencing Roost re-use	Intermediate	Determine density of suitable roosts required	Moderate
Species Response to Stand Level Changes	Intermediate	Understand the impact of stand level changes on distribution	Moderate
Daily Movement Patterns	Intermediate	Ensure management of all habitats required	Moderate
Foraging Behavior	High	Ensure management of all habitats required	High
Demography and Metapopulation Structure	Low	Allow predictions about habitat change on demographic and genetic structure of BHNF population of <i>Lasionycteris</i>	High

*Low: would refine or improve silver-haired bat management strategies; Intermediate: is required to develop comprehensive management strategies; High: is required to develop minimal science-based management strategies.

**Low: estimated cost \$5,000-\$25,000; Moderate: estimated cost \$25,000-\$100,000; High: estimated cost >\$100,000.

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